



Solar thermal systems for high rise buildings with high consumption demand: Case study for a 5 star hotel in Sao Paulo, Brazil



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ABSTRACT

Solar thermal has been consolidated as a renewable energy solution for new buildings during recent years. Although this system has been easily integrated in low-rise buildings, a continuous challenge is the integration of solar thermal into the demanding architectural solutions for high-rise buildings. This article presents solutions for solar water installations in high rise buildings. It describes the integration of solar collectors into the building, hot water distribution installation and proposes a solution to minimise the risk of exposure to Legionella. As an example of the requirements of solar thermal in developing countries, the article analyses the development of the solar hot water standards in Brazil, where although there is a draft document for a federal standard, cities like Sao Paulo have already in place solar thermal requirements for any new building in the city. In order to promote the development of renewable integration, initiatives like PROCEL certify buildings energy performance if they meet the improved target, compared to regulatory requirements, of generating a minimum of 60% of hot water using solar thermal. The presented case study for a 5 star hotel clearly justifies the installation of solar thermal systems in buildings with a high demand for hot water.

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1. Introduction

The solar energy used to generate heat is one of the oldest solar energy resources. However, it was necessary to wait until the mid 1950s to see the first commercial building with a solar thermal solution. The architect Frank Bridgents designed the first world commercial building using solar water heating and passive design [1].

In Brazil, the first solar thermal systems were installed in the 1970s, but it was not until the 1990s when the systems start to be installed in a professional way, in answer to a demanding market and the development of the Brazilian legislations and standards ABNT for the solar thermal sector.

Although solar thermal has been used the last years in dwellings, at present, due to the new regulations, the applications of solar water heater in new construction buildings is compulsory. This is giving a boost to the solar thermal market.

There are two major issues related to the integration of solar water heating system in buildings. One is the integration of the solar heating collectors into the architectural design. The amount of solar collectors required to cover the water demand required in the regulations require a large space, so the roof of the buildings are not providing enough space for the number of collectors required,

therefore the facades of the buildings and surrounding areas need to be explored for the location of the collectors. This issue, that is becoming really difficult for the architects, is even more important in buildings with large water consumption like hotels or hospitals.

The second issue is the integration of the technical equipment (water tank, pumps, pipelines, etc.) within the building. This is not a major problem in low rise building where the water heater plant is associated to the gas or electrical support water heater and the pipes are shared, however it is more challenging for high rise buildings where the height of the building affects the pressure in the vertical pipes, requiring specific solutions.

Due to all these challenges, this paper will focus on the study of solar thermal systems for high rise buildings based on a case study of a proposed hotel in Brazil, in the highly populated city of Sao Paulo.

2. High rise buildings

With the development of the urban residential construction, growing due to the growth of the economy in Brazil and people moving into the cities, the urban population has been rising in the cities in Brazil, encouraging a fast development in the building industry [2].

The beginning of the high rise in Brazil was in 1920s, promoted by an import-substituting industrialisation, with special impact in Sao Paulo, but it was in the last two decades when it became

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important either in cities where high rise building existed before and cities where they were not [3].

For cities like Sao Paulo with a city centre where the price of the land is growing continuously, the high rise construction is the way to build profitable developments, building upwards as to minimise the cost of the land as per the total area of the building. In this way, the same land can provide more offices, apartments, commercial areas, hospitals or hotel rooms.

This is the reason why in the 1980s and 1990s a good number of high rise office buildings were built in Sao Paulo. The growing economy in Brazil and Sao Paulo working as a business hub for Latin America, invited business people to set up their offices in this city. As a consequence high rise building hotels were built to provide accommodation to the international visitors.

Hotel high rise buildings have large water consumption, so it is clear that they could get clear benefits for the solar thermal technology, saving energy from non renewable sources like gas or electricity produced with coal.

3. Solar thermal regulations and standards in Brazil

The experience has shown in several countries that political support has a big impact in the development of renewable energy systems. In order to be successful, the political policies have been created, complying with the following basic requirements:

- Long term policies well developed and implemented.
- Establishment of a clear scope.
- Support activities to the policies:
 - o Disseminations policies.
 - o Training programmes.
 - o Financial schemes.

The policies are the base for discussion and development of local, regional and national regulations to encourage the use of solar thermal systems in buildings.

Currently in Brazil is not compulsory the installation of solar thermal systems in the whole country. There are regional regulations already developed for the regions of Sao Paulo and Rio de Janeiro. Some of those areas also developed local regulations to standardise specific requirements not covered by the regional regulations.

Below there is a list of approved solar thermal regulations in Brazil:

Regional regulations

- Sao Paulo. Lei N° 326 (2007) Installation of solar thermal systems in public buildings [4].
- Rio de Janeiro. Lei N° 5184 (2008) Installation of solar thermal systems in public buildings [5].

Local regulations

- Sao Paulo. SP–Lei 14459. Installation of solar thermal in new buildings [6].
- Sao Paulo. Decreto N° 49.148. Regulates the Lei 14.459–Solar thermal system [7].
- Sao Paulo, Peruipe. SP–Lei 2883–2007. Installation of solar thermal system in public and private buildings [8].
- Minas Gerais. Lei 31–2006. Lei 31–2006. Installation of solar thermal or gas boilers in hospitals, schools and nurseries [9].

Also at the time of writing there are already several regulations waiting for approval. Among them there are two national

Table 1
Benchmark for hot water consumption in hotels, l/guest-night.

Room/area	Daily (litres)	Stored (litres)
Hotel room 4/5 star (room, 2 guest)	72 (36l each)**	45*
Large Spa (swimming pool, per person)	20*	20*
Dinning (Restaurant, per cover)	12 **	6*
Meeting space	2*	1*
Breakfast bar (per person)	2*	1*
Canteen Staff	15*	5*
Ballroom (Restaurant, per cover)	12 **	6*
Gym (per person)	20*	20*

Source: *[19] and **[18].

regulations that will have an impact on the use of the solar thermal in Brazil:

- Projecto de Lei 478330-2007–It makes compulsory the use of solar thermal in buildings with financial support from organisations like SBPE, FGTS, FAT or OGU [10].
- Projecto de Lei N° 1563-2007 - Use of renewable energy resources for distributed energy generation in Brazil [11].

Apart from the federal (national), regional and local regulations that regulates the use of solar thermal in different type of buildings, technical standards to standardise the way the systems are sized, dimensioned, installed and maintained.

- ABNT NBR 15569:2008 Solar thermal systems with direct circuit – Project and installation [12].
- ABNT NBR 15747/1:2009 Solar systems and their components – Solar Collectors – Part 1 – General requirements [13].
- ABNT NBR 15747/2:2009 Solar systems and their components – Solar Collectors – Part 2 – Test Methods [14].

4. Water consumption in hotels

The hotel industry is an important sector of the tourism industry with a growth in Brasil of 17% in 2011 over 2010 [15]. This hotel business accounts for a significant amount of resources consumption and environmental impact it generates. Hotel facilities are among the top five in terms of energy consumption in the commercial building sector (minor only to food services, health care, and certain type of offices) [16]. Giving a number, Bohdanowicz estimates that European hotels emit more than 10Mt of carbon dioxide annually [17].

Bohdanowicz studied that the consumption profiles of hotels differ from the other commercial buildings [16]. Factors influencing facility performance can be classified into physical and operational parameters. The physical parameters are common to most buildings like, size, structure and building design. Operational parameters like type of energy and water systems installed, operation and maintenance, depend on each particular building.

The resources used in hotels are influenced also by operational features like operating schemes, catering outlets, laundries, swimming pools and spas, recreational and business centres, services offered and fluctuation in occupancy levels.

Hot water is a big part of a hotel facility' consumption, which is attributable mainly to the guestrooms, swimming pools, and in kitchen and laundry operations. Table 1 shows benchmark values based on the Brazilian standard NBR 7198/82 [18] and the UK Plumbing Engineering Services Design Guide [19]. Although the Brazilian standard has been superseded by the NBR 7192/93 [18] which does not contain any table for the consumptions, the values are still widely used by engineers and manufactures in Brazil.

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